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C. E. HELLER
CONSULTING ENGINEER
SAN FRANCISCO, CAL.

FIRE ENGINE TESTS

AND

FIRE STREAM TABLES

NATIONAL BOARD OF FIRE UNDERWRITERS
New York

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PREFACE.

This pamphlet has been prepared for the purpose of assisting fire department officials and others who may wish to determine the condition of fire engines. It may also be of service in testing the capacity of new engines with a view to their acceptance by a city.

Tests similar to those outlined herein have been adopted by many fire departments and are being made by our engineers in their investigation of cities throughout the country, so that by corresponding with this Board, the location of the nearest field party may be ascertained and if desired, an opportunity afforded to observe such tests.

The appended fire stream tables, on pages 30 to 51, are based on tests of rubber-lined fire hose made in October, 1909, by our engineers, with the assistance of the New York Fire Department and the co-operation of the Department of Water Supply of New York City. These tables may also be used to find the approximate amount of water used at a fire, if engineers will observe from time to time the water pressure carried and the length of time at work. With an approximate average of the water pressure at each engine, the amount of water delivered per minute can be found for each line if the size of nozzle and length of hose is also known. Copies of this pamphlet will be sent to such captains of companies and engineers of steamers as would use them in keeping accurate records of the performance of their engine at fires.

NATIONAL BOARD OF FIRE UNDERWRITERS.
Committee on Fire Prevention,
76 William Street,
New York.

August, 1915.

M85664

PRACTICAL TESTS FOR FIRE ENGINES.

It is the purpose of this manual to set forth convenient and practical methods of making fire engine tests which will show the physical condition of engines, their capacity for delivering water at a reasonable pressure and the ability of the operating crews. The method described has been in use for a number of years and has been found practical, exact and of great value. Although methods similar to that described below are in use in some departments, the character of tests made in many cities, and especially those for acceptance, are usually more spectacular than exact. The throwing of a stream over a church spire, city hall or court house does not necessarily show that the engine is capable of delivering its full rated capacity at a proper working pressure.

Investigation has shown that where regular and systematic tests of engines are not made, even in well managed fire departments, defects often exist which may continue unsuspected for considerable periods and become manifest under the stress of a large fire, where the engine is called upon to deliver its full capacity under suitable working pressures. Furthermore, regular tests are a most valuable drill for engine crews, for in only a few departments do they receive sufficient training in operating engines to capacity. The breakdown of an engine at a fire or the inability of the crew to operate it to capacity may be the direct cause of confusion and the needless loss of property and perhaps of life, to the discredit of the department.

Contracts for new fire engines usually contain guarantees that the engine will deliver a certain quantity of water, but often do not specify the pressure at which it is to be delivered, nor provide for any definite tests which will accurately determine whether the engine has fulfilled the guarantee; or, in other words, if the department is getting what it is paying for. In several cities, engines are required to fill large measured tanks in a specified time, but this is a cumbersome method at best, and such tanks are frequently unavailable; this usually gives no definite results as to pressure obtained and power developed.

STEAM FIRE ENGINE

A practical test should show, with fair accuracy, the condition of both water and steam ends of pumps and the condition of the boiler; determine the amount of water which the engine will pump at a reasonable working pressure, such as would be required when operating at a large fire; demonstrate the ability of the engine to draft water, whether the pumps and waterways are tight under high pressures and steam valves are properly set, and whether the coal used is quick steaming and free from objectionable impurities. In addition, the test should be of such a character as to approach the working condition at a serious fire where the full capacity of the engine would be required, and at the same time be easily understood. The following tests are intended to bring out all of these points.

The displacement test indicates very closely the actual condition of the pumps as a whole and, in conjunction with the high pressure and valve tests, the condition of the plungers, pump valves, packing, etc. The high pressure test, in connection with the results obtained from the capacity test, indicates the setting of steam valves and condition of steam cylinders and packed joints. The capacity test shows the steaming quality of the boiler under heavy draft and the ability of the engine to make sufficient speed to develop its capacity when working against a reasonable water pressure. If the test is made from a cistern or reservoir, it will show the ability of the engine to draft; if made from a hydrant, the percentage of slip obtained will indicate this feature, as an engine showing less than 7 per cent. slip may be depended upon to take suction satisfactorily. Incidentally, the test also shows the ability of the engine crew in operating and stoking the engine.

Any machine, when new, should be capable of greater work than after several years of service; for this reason, a new engine should be given an acceptance test at least as severe as any work it may have to perform in actual service. This test should bring out not only the capacity to pump the actual volume of water specified by the maker as the rated capacity, but also to do this at a good working pressure.

A good specification, applying equally well to steam fire engines and automobile fire engines, is that the engine should de-

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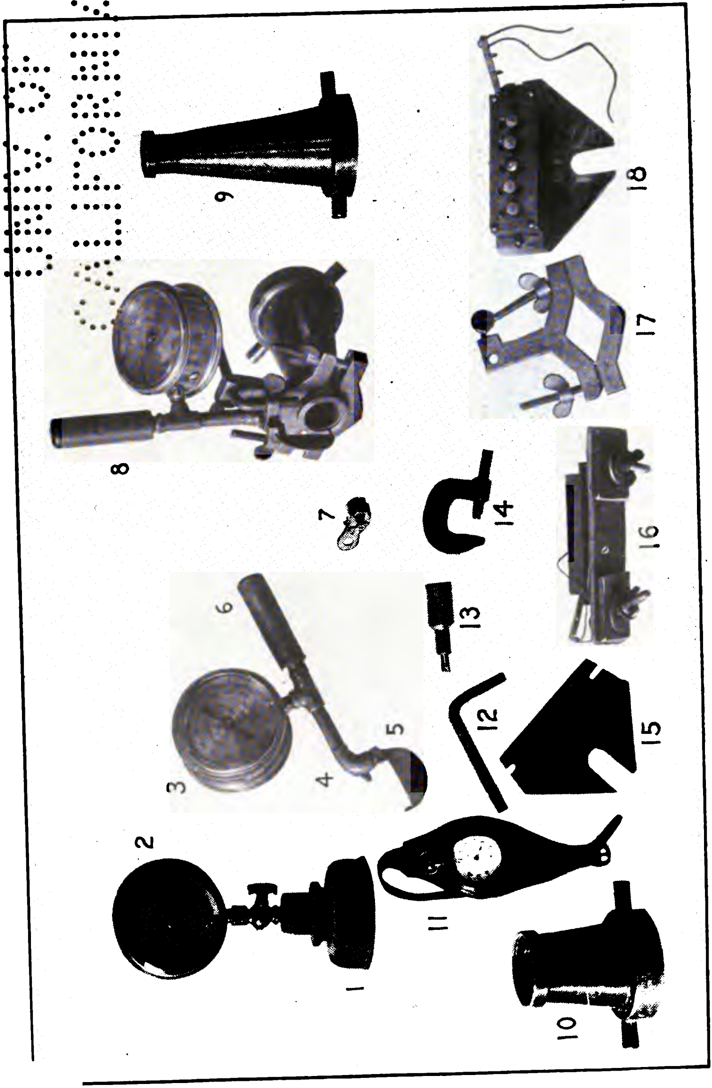
PLATE I.
APPARATUS FOR TESTING FIRE ENGINES.



liver its full rated capacity at 120 pounds net pressure and 50 per cent. of its rated capacity at 200 pounds net pressure. This will assure sufficient boiler capacity in steam fire engines and motors of high enough power in automobile fire engines.

Engines in service need not be given as severe a test as those being accepted, as it is mainly their general condition that is to be ascertained; for this reason, 100 pounds net water pressure would seem a sufficiently high requirement for the ordinary capacity test, which should be made at least yearly.

Apparatus Necessary for Testing.—For the tests outlined below, no elaborate or costly outfit is needed, the only special appliances absolutely required being as shown on Plate I and listed below:

A revolution or speed counter. (Figures 7, 13 and 18.)
A stop-watch and wrist strap. (Figure 11.)
A small Pitot tube. (Figure 5.)
An air chamber on Pitot. (Figure 6.)
Two or more pressure gauges. (Figures 2 and 3.)
A set of smooth-bore nozzles. (Figures 9 and 10.)
A hydrant or engine-discharge cap. (Figure 1.)
Appliance for attaching counter. (Figures 14 and 15 or Figure 16.)

For convenience, it is desirable to have a Pitot bracket. (Figure 17.)

This is shown attached in Figure 8, with a special form of elbow (Figure 4) and ¼-inch bent rod. (Figure 12.)

The revolution counter should be of a type easily attached to the engine frame, or any convenient part, and so made as to register accurately at any speed likely to be reached by a reciprocating engine and be easily read.

The counter may be provided with straps for attaching to engine, or with the clamp and angle iron shown on Plate I, Figures 14 and 15, or with bolts and slotted lugs as shown in Plate I, Figure 16.

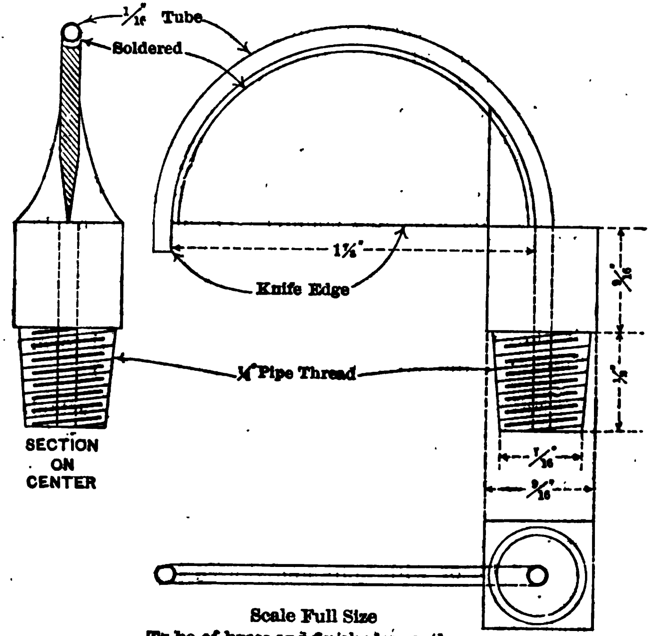
For high speeds, and particularly where the speed is uniform, as with motor-driven pumps, the speed counter, Figure 13, is best; 30-second or 1-minute readings can be taken from some shaft at frequent intervals.

Most tachometers and speed indicators are unsuitable for steam fire engine work, as the vibration is apt to render their readings unreliable and the variation in speed makes their readings of little value.

A stop-watch can be purchased for less than $15, although an ordinary watch can be used.

The Pitot tube may be any of several suitable types now on the market, or the type shown on Plate I may be readily constructed. Dimensions are given below. It should be connected by ¼-inch brass pipe fittings to a pressure gage; to prevent vibration of the needle, an air chamber should be provided as shown on Plate I.

NOZZLE STREAM PITOT



Scale Full Size
To be of brass and finished smooth

The pressure gages should be preferably not more than 3½ inches in diameter, in order that they may be conveniently handled. They should be without a rest pin for the needle, in

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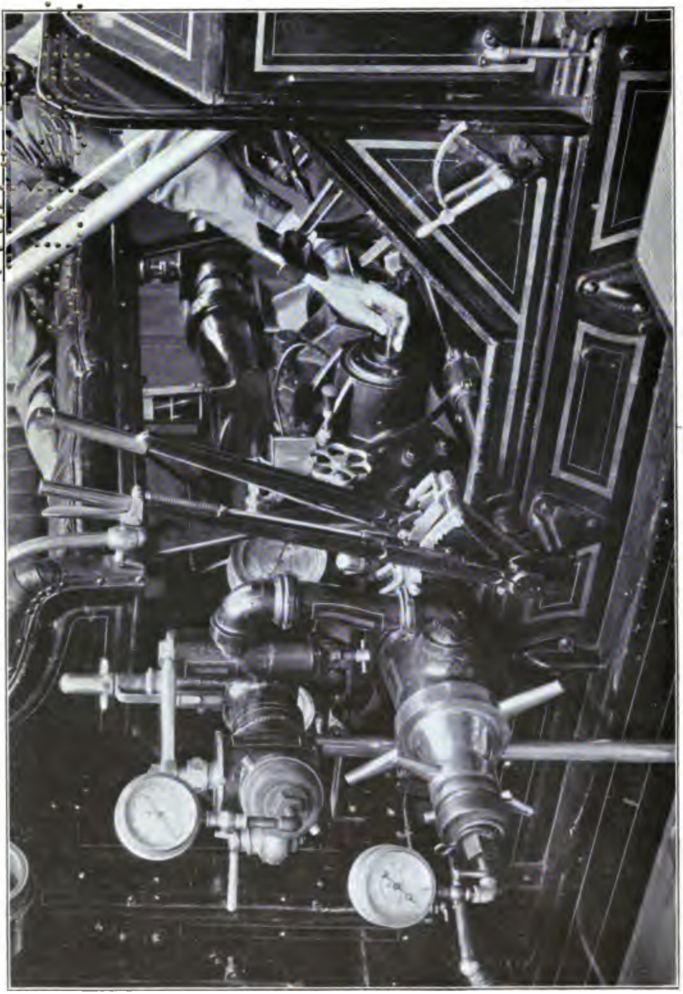
PLATE II.
METHOD OF ATTACHING GAGES AND COUNTER FOR TESTING PUMPERS.



order that any disarrangement of the needle may be readily observed; one capable of indicating a vacuum should be provided if a gage is used on the suction; the Pitot gage should read up to 200 pounds, and be divided preferably for every pound and marked every 5 or 10 pounds; the pressure gage should read up to 300 pounds, and where tests to 250 pounds are made, to 400 pounds, and may be divided only for every 5 pounds. Gages, especially those used with the Pitot, should be of good quality and accurate. They should be carefully calibrated (tested) with a weight tester or a standard gage before each day's work.

Nozzles suitable for testing are usually found in the regular equipment of every fire department. Only smooth-bore tapered nozzles should be used, as discharges from ring nozzles are uncertain. Care should be taken that the tips are not nicked or otherwise injured, and that washers do not project into the pipe, as a perfectly smooth waterway is essential. The ring nozzles on many engines have loose rings, which may be slipped out by unscrewing the end cap, leaving a suitable smooth-bore tip. Shut-off nozzles should not be used, as these generally have interior projections or breaks in the waterway, likely to cause eddies in the stream. Where much testing is to be done, it is better to set aside nozzles, keeping them solely for that purpose. The bore of nozzles should be accurate to size within 1/1,000 of an inch and carefully measured.

The engine-discharge cap, or hydrant cap (in most cities these have the same thread) is tapped for ¼-inch pipe thread and fitted with a nipple and stop-cock for attaching the test gage. By attaching to the discharge outlet of the pump, as shown on Plate II, the water pressure gage and the test gage may be compared to determine if the pump gage is correct. Where there is time to detach the water gage and a testing set is available, the gage can be more accurately checked. The steam gages are less likely to get out of order, being less subject to sudden fluctuations, and a comparison of readings of side and rear steam gages will usually be sufficient. If the engine has no suction gage or tapped suction cap, the engine or hydrant cap should be used on the second outlet of the hydrant when testing an engine at a double outlet hydrant.

... Tests are best made by a supervisor (as the master-mechanic or other officer conducting the test will hereafter be called), with an assistant accustomed to reading gages. Tables showing the discharge at various pressures through different nozzles, for use with Pitot tube readings, are to be found on pages 28 and 29. A suitable form for recording data of tests is shown on page 16, and until the supervisor becomes familiar with tests, it is advisable to use a similar form at the tests in order not to overlook any necessary data. Later, a pocket note-book will doubtless be found more convenient, care being taken to record all the necessary data.

Preliminary to Test.—If possible, calibrate gages of engine before the test, by detaching and comparing on a portable gage-testing set. They should be calibrated in the position in which they are to be tested, either horizontally or vertically. If this is not done, check water and suction gages at test, as explained below.

If it is desired to determine the ability of the regular engine crew, the engine should, of course, be operated by them; if the condition and capacity of the engine are the unknown factors, a crew known to be efficient should be selected.

If there is any convenient body of water, or cistern, where water may be drafted with about 10 feet of life, then test should be made at draft; otherwise, attach engine to hydrant, care being taken to get a hydrant attached to a large main (8-inch or larger), and that the hydrant pressure is not excessive, preferably below 40 pounds. Four-inch or larger suction should be used. After suitably stationing engine, light the fire; note the time when smoke comes from stack, when steam gage needle moves, at 50 pounds of steam, at 100 pounds, and pressure and time of blowing off. If engine has hot water in boiler, this may be omitted, noting only the pressure at which safety valve blows off. Then, if water gage on engine has not been calibrated (checked), attach hydrant cap and 200-pound test gage to pump discharge outlet, as shown on Plate II. Record zero of all three gages—water, suction and test gages; open hydrant and record static pressure on all three gages; then with churn (hand relief) valve partly open and discharge gates shut, pump up pressure and compare test and water gages at 80 pounds, 100, 110, 120, etc., up to 120 pounds over the static or hydrant pressure. If engine has no suction gage, one of the suction caps on the engine can be tapped to connect the gage, as shown on Plate II, or the engine or hydrant cap provided with the second gage should be attached to one hydrant outlet.

Let supervisor and assistant compare watches and set second hands together, or nearly so; this is more quickly accomplished if one watch has a stop-hand. The supervisor will find it convenient to tie his watch to coat or wrist in order to leave his hands free to hold note-book or Pitot. A leather watch holder and wrist strap, as shown on Plate I, such as any harness maker can make, is a convenient appliance for this purpose. Attach the revolution counter and connect with one of the eccentric strap oil cups or studs by a short length of cord; have engine started slowly and adjust counter cord so that each revolution registers.

Displacement and Capacity Test.—While the engine is getting up steam have firemen lay hose and connect nozzle. If testing on a paved street, it is best to lay nozzle down in gutter. Use a play-pipe holder or tie nozzle to any convenient post, in order to prevent pipe getting away from pipeman and doing damage.

For the larger engines, attach a line of hose on each side of the engine and connect into the siamese of a deluge set.

With the smaller size engines it is usually more convenient to use a single line from one side of the engine; when deluge sets are not available, single lines may be used on the larger engines. In the tables on pages 20 and 21, the length of hose and size of nozzle best adapted for testing engines of various sizes are given. In testing with the siamesed lines, start the engine with both lines open and bring it up to speed; if the desired water pressure is not obtained, close the discharge gate on one line slowly until the gage indicates the proper pressure. Similarly, with a single line attached, the gate is closed slowly after engine has obtained its full speed until the desired pressure is obtained.

The supervisor can, from time to time, regulate this discharge gate to keep the desired water pressure, although if the crew operates the engine properly but little change will have to be made throughout the test. The engineer can be instructed to direct all his attention to operating his engine to full capacity, and the supervisor or testing engineer can regulate the water pressure, take the readings of the revolution counter, steam, water and suction gages, while his assistant takes readings of the nozzle pressure throughout the test.

When siamesed lines are used, should the engine not be able to maintain the desired water pressure with one line shut off entirely, add another length of hose to each side, or use a nozzle ⅛-inch smaller. With single lines, when the engine cannot maintain the desired pressure without undue throttling of the discharge valve, use a smaller nozzle or add another length of hose. The nozzle readings should, if possible, be over 40 pounds, as below this point readings must be very nearly constant to give accurate results.

Should water pressure at the engine be too high with both lines wide open, use a larger nozzle or cut out a length of hose from each side.

Relief valves should be closed, sprinkler used only as needed, and feed pumps operated regularly. The capacity test should last at least 20 minutes from the time the engine reaches full speed. During this time the water pressure at the engine should be constant and such as to give a net water pressure over the suction pressure of 100 to 120 pounds. Unless the rubber tires cause undue vibration, a modern engine, if in good condition, can safely run for an indefinite period at 400 to 425 feet of piston travel per minute, that is, 300 to 320 revolutions for an 8-inch stroke.

It is usually better to hold about 10 pounds over the pressure actually required, when the water pressure fluctuates much, as most engineers read the top of swing of a gage needle, while the supervisor, of course, should read the middle of the vibration. Gages may be throttled to prevent excessive vibration, but should always show some vibration to get true readings. A better method of preventing excessive vibration of needle on gage is to attach a small air chamber to the connection near the gage; such an appliance is shown attached to gage used on Pilot tube. During the capacity test, the supervisor should read counter (exactly at minute) and steam, water and suction gages each minute in regular order, and note the

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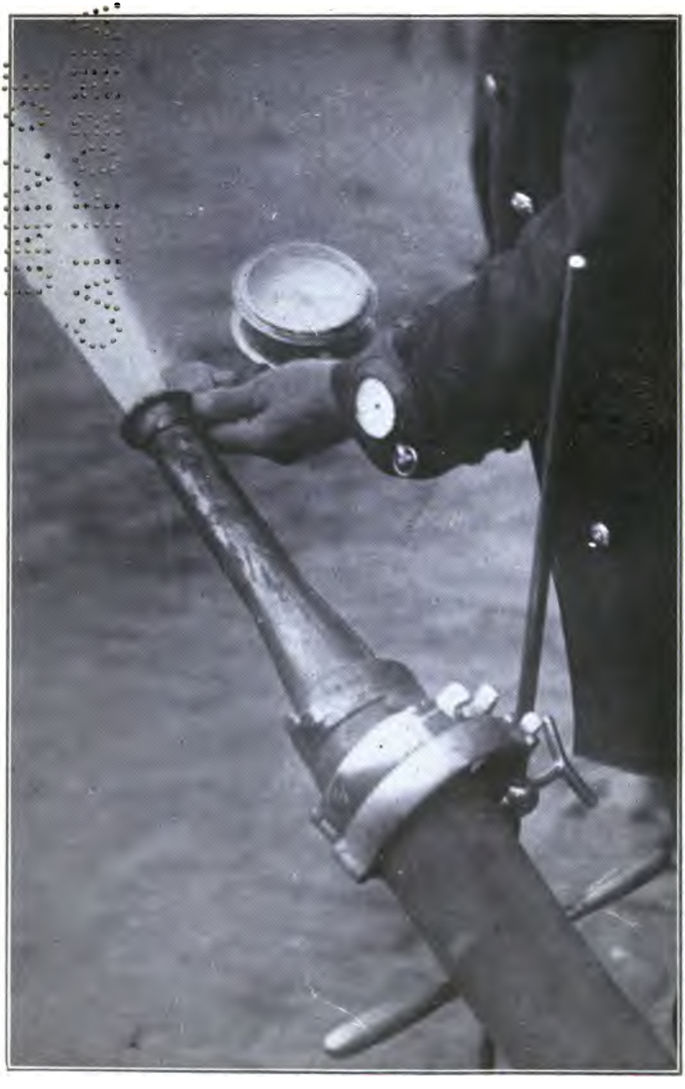
PLATE III.
SHOWING USE OF PITOT AT NOZZLE.



handling and stoking, feed water, leaks, uneven steam pressure, blowing off, foaming of boiler, accidents, and the other little details which his experience teaches him to observe. Meanwhile the supervisor's assistant should read the nozzle pressure every ¼ minute. Special care should be taken in reading the nozzle pressure. The Pitot should be held in the middle of the stream, with the tip about one-half the diameter of the bore from the end of the nozzle. Gage should be horizontal or vertical, according to the position in which it was calibrated, and at approximately the same level as the end of the nozzle. This is shown on Plate III.

High Pressure Test.—After a run of 20 minutes in which there were no serious interruptions to readings, and pressure was maintained at an average of at least 100 pounds net, stop stoking; shut down, close discharge gates, partly open churn valve and get steam down to between 70 and 80 pounds, drawing fire if necessary. Then start engine slowly, and gradually close churn valve tight. See that all other openings, feed pumps, sprinklers, relief cocks, etc., are shut. Let engine turn in this condition for one or two minutes; observe the number of revolutions, and the water, steam and suction (now static) pressures; note any uneven motion of engine, blowing through of steam or imperfect valve setting, leaks in steam or water ends, or fittings, etc. If pumps are in good condition and valves set correctly, speed should not be over one revolution in 10 seconds in any modern type engine. (This does not apply to a Silsby or a Button.) With 70 pounds steam and 50 pounds suction, water pressure will reach about 250 pounds; this is perfectly safe and not a severe test, as such pressures are frequently met in operation when long lines are used.

Valve Tests.—After taking the observations for the high pressure test, shut off throttle of engine and open cylinder drips. Note the drop in water pressure for say one-half minute. The manner in which this pressure holds up is an indication of the condition of the discharge valves. A drop of not over 15 pounds in one-half minute, provided there are no external leaks visible around the pump, indicates a fairly good condition of the valves.

Suction Test.—If the engine has been tested at a hydrant, its ability to draft may be determined as follows, provided it is equipped with a compound suction gage or one of the suction caps is tapped to receive a compound gage: Disconnect engine from hydrant while there is still some steam pressure on boiler, put both suction caps on tight, open one of the discharge gates and then open throttle, allowing engine to run at a moderate speed, observe the reading of the compound gage while running, and also after shutting down. The drop of the vacuum after shutting down is an indication of the condition of the suction valves, provided all joints are good.

To Figure Displacement.—(Displacement is figured as indicated for sample test, pages 16 and 17.) In averaging the nozzle, steam, water and suction pressures, subtract ½ of first and last readings from sum of readings used (see page 17 and sample test sheet). Average the nozzle pressure during a period in which the engine ran steadily, water pressure was well maintained and the nozzle pressure varied the least. When possible, use a 20-minute period in figuring the displacement; if for any reason there is much variation in the nozzle pressure, say over 10 per cent. during any one minute, select as long a period as possible, but at least 10 minutes, during which the pressure has been well maintained. Correct for gage error. Take out corresponding gallons from table, pages 28 and 29, interpolating for odd pressures or for odd-size nozzles.

Example: 1½" nozzle, 61 pounds nozzle pressure.

62 pounds nozzle pressure gives.................. 525 gallons
60 " " " " .... 517 gallons

or 2 pounds give a difference of.................. 8 gallons
and 1 pound gives ½ of this, or.................. 4 gallons
Therefore, 61 pounds nozzle pressure..........=517+4
=521 gallons

Example: 1 9/16" nozzle, 60 pounds nozzle pressure.

60 pounds through 1⅝" nozzle gives.............. 607 gallons
60 " " 1½" " " .... 517 gallons

or ⅛" difference in nozzle diameter gives........ 90 gallons
and 1/16" " " " " " .... 45 gallons
Therefore, 1 9/16" nozzle at 60 pounds gives.. 517+45
=562 gallons

For odd-size nozzles, the discharge can be accurately obtained by using the formula on page 24.

Divide the average gallons discharged by the average revolutions per minute to obtain the actual net displacement of the pumps. The nominal displacement will be found from the table, page 18, allowing for the pump rods. The dimensions of the pumps, such as stroke, diameter of pump barrel and pump rods, should be accurately measured, if in question. The difference between actual and nominal displacements is the slip, which should be from 3 to 5 per cent. of the nominal displacement in a new engine (6 per cent. in a rotary); of this, about ½ per cent. is due to the feed water (1 per cent. with a Button or Silsby engine). After engine has been in use a few months, slip will generally increase about 1 per cent.; therefore, if valves and packings are given proper attention, there should be only a slight increase. A slip of 10 per cent. or over indicates broken or displaced valve springs, and more than this, a badly worn plunger or pump barrel, or possibly a leaky suction. In a rotary, the wear is principally in the pump cam slides, which will also stick at times, causing increased slip even if not worn.

To Figure Capacity.—When the engine is run for 20 minutes at a uniform speed during the displacement test, the average discharge measured at the nozzle by the Pitot is the capacity of the engine. If only a 10-minute period of the run is used for figuring the displacement, the capacity of the engine is determined by multiplying the actual displacement (found in the displacement test) by the average revolutions per minute during a 20-minute period in which the engine worked at its full capacity. Steam, water and suction pressures during the capacity run should be averaged and corrected for gage error. In figuring percentage of capacity delivered, for a new fire engine, it is well to use contract figures for the rated capacity which the engine is guaranteed to deliver. A capacity due to a piston travel of 400 to 420 feet per minute (300 to 315 revolutions for 8-inch stroke) less a 3 per cent. allowance for slip, is reasonable for a modern engine; older types vary considerably.

AUTOMOBILE AND MOTOR DRIVEN FIRE ENGINES.

In so far as they apply, the same tests are desirable for automobile and motor driven pumping engines as for steam fire engines; the same methods for measuring the water discharged, calibrating (testing) water gages, calculating the actual and nominal displacement and slip of the pumps, and averaging the net water pressure may be used. Valve and suction tests (page 11) may be made in much the same manner as with steam fire engines, for piston or rotary displacement pumps; for centrifugal or rotary gear pumps, they will not apply.

Owing to the characteristics of the gasoline motor, certain modifications and additional tests are advisable. The capacity test should be run longer than is usually necessary with a steam engine. It is suggested that, for acceptance, engines of this type be required to deliver their full rated capacity at 120 pounds average net pressure for 2 hours, 50 per cent. of their rated capacity at 200 pounds average net pressure for ½ hour, and 33 per cent. of their rated capacity at 250 pounds average net pressure for ½ hour. Tests should preferably be made when drafting with about 10 feet of lift, especially if the engine may be required to draft water from a river, canal or cistern when in service. With a motor driven pump the high pressure test recommended on page 11 for steam engines becomes inadvisable. The ½-hour runs at high pressure serve to show the action of motor and pump under high pressures, and whether the gear ratios are properly arranged. The tables on pages 20 and 21 may be used to determine the length of hose and size of nozzles to be used with an engine of any given or guaranteed capacity. If two streams are preferred for the capacity test, the tables beginning on page 30 will be found convenient in laying out the length of hose and size of nozzles to be used. If the relief valve connection between discharge and suction side of pump is small or tortuous, it may be desirable to make an additional test with an 1⅛-inch shut-off nozzle on a line of about 300 feet in length, and with the engine pumping at 120 pounds pressure. The relief valve should be set to operate at about 10 pounds higher than the pressure to be carried, and when the nozzle is closed should permit the engine to run with an increase of not over 30 pounds pressure. The motor should start the pump readily with the hand relief valve open and the discharge gates closed.

For a two-hour run, nozzle and engine pressures may be recorded every 5 minutes, after the engine is brought up to speed, as with any reliable motor the speed and pressure will be nearly uniform. If it is inconvenient to attach a continuous reading counter to the pump the speed may be taken for one minute, during each five-minute interval, using a speed counter. On some makes of pumps it is feasible to take the pump speed directly from the end of the pump shaft, by removing a foot board or bracket (see Plate II); on other makes, speed may be taken at the engine, on the end of a circulating pump shaft, timing shaft, or possibly on the fan drive-wheel shaft; if pump speed is obtained, the engine speed may be computed from the gear ratio. Notes should be made of any faults of construction, such as: Clutch slipping, absence of locks or stops for control levers, inadequate gasoline or lubricating oil supply, inaccessibility of parts, magneto and sparking circuit not waterproof, etc. The feed of lubricating oil is especially important in an automobile pump, where many parts are enclosed or not quickly accessible, and should be carefully looked into by the supervisor.

A. L. A. M. FORMULA FOR HORSE-POWER OF GASOLENE MOTORS.

$$\text{Horse-Power} = \frac{\text{Bore} \times \text{Bore} \times \text{No. of Cylinders}}{2.5}.$$

Example.—Six-cylinder motor, 4½-inch bore.

$$\text{H-P.} = \frac{4\frac{1}{2} \times 4\frac{1}{2} \times 6}{2.5} = 48.6.$$

REASONABLE CAPACITIES OF MODERN FIRE ENGINES.

Bore of Pumps, Inches.	Stroke, Inches.	Capacity, Gallons per Minute.
6	9	1,100
5¾	8 or 9	1,000
5½	8	900
5¼	8 or 9	850
5	8	750
4¾	8	700
4½	7 or 8	600
4¼	7 or 8	550
4	7	500

RATED CAPACITY OF SILSBY ENGINES.

Maker's Size.	Nominal Displacement per Revolution, Gallons.	Rated Capacity, Gallons per Minute.
Extra First	1.261	1,000
First	1.141	900
Second	0.952	700
Third	0.804	600
Fourth	0.675	500
Fifth	0.513	400

LOG OF FIRE ENGINE TEST

City ________ Engine No. 5 Make ________ Builders No. ________
Tested by A.C.B. & H.N.C. Location Rear of quarters Date 11-9-09
Run by Regular engineer Fired by Regular asst engineer Coal Jackson lump

ENGINE: Size Second Type Double piston pump Rated Capacity 700 Built 1907
DIMENSIONS. Cylinders 8" Pump Bore 4¾" Stroke 8" Pump rods 1⅝"
BOILER: Type ________ Diameter 54" Height 64" Built 1907

GAGE COMPARISON		NOZZLE PRESSURE										
TEST GAGE NO. US	WATER GAGE	Min.	¼	½	¾	TIME	COUNTER	R.P.M.	STEAM	WATER	SUCTION	NOTES
0	1	80	81	80	81	3.39	7170		132	140	35	Engine at hydrant.
90	91	80	82	80	81	40	8178	308	125	140	37	1 length 9' of 4" soft suction
100	101	82	84	87	86	41	8486	308	135	140	40	Boiler hot; fire lighted
120	122	88	88	90	92	42	8797	311	135	145	35	at 3.15, steam 50# at 322
140	144	90	93	93	92	43	9119	322	135	145	34	Small safety set at 130#
150	151	93	92	92	92	44	9442	333	132	145	35	Large safety set at 135#
160	161	91	91	91	90	45	9774	332	134	148	32	Hose Lay-
		90	89	90	92	46	103	329	130	145	33	1 line 150'; 1 line 100'
Slate		94	95	96	98	47	430	328	135	145	32	2½ C.R.L. Siamesed
60	62	97	96	93	92	48	759	328	135	145	32	to deluge set Nozzle 1⅝
Suction		90	90	87	84	49	1093	334	129	155	38	(1.625") smooth bore.
gage 67		82	86	83	87	50	1422	329	120	155	36	Check marks indicate
		86	87	86	87	50	1739	317	138	142	35	large safety valve opened.
		92	93	96	97	52	2063	324	140	150	35	Crew O.K.
Pitot gage [illegible]	Engineer	95	95	94	95	53	2395	332	140	145	35	
		91	96	92	90	54	2728	333	132	155	35	
		87	86	90	90	55	3048	320	132	140	38	Engineer regulates with feed
		92	87	91	95	56	3378	330	135	150	40	water.
		94	92	92	88	57	3708	330	140	150	35	Stoker carries even fire.
		86	88	92	93	58	4032	324	124	140	40	Fuel satisfactory.
		90	1791	1795	1800	59	4358	326	135	145	35	Engine runs smoothly
		1870										
		85										
		1785										

DISPLACEMENT TEST

Time 3.39-59	= 20 min.
Ave. noz. pres.	89.7
Corrections.	+2
Corrected pres.	91.7
Gallons per min.	749.8
Revs. per min.	324.4
Displacement	2.311
" (nom'l)	2.370
Slip per cent	3

CAPACITY TEST

Duration mins.	20	
Ave. r.p.m.	324	
Gallons per min.	750	
	[illegible]	[illegible]
Ave. steam pres.	133	
Ave. water pres.	146/	145/
Ave. suct. pres.	35.6	36.6
Net water pres.		109.5

HIGH PRESSURE TEST

TIME	COUNTER	R.P.M.	STEAM	WATER
4.05	5228		72	220
4.06	5230	2	72	200

REMARKS: No leaks

Reasonable capacity of engine 700 gallons. Obtained 750 gallons or 107% of rating

VALVE TEST

TIME	WATER
4.07	130
4.08½	125

SUCTION TEST

TIME	SUCTION GAGE
4.10	20"
4.11	20"

Figured by A.C.B.
Checked by H.N.C.

CALCULATIONS FOR ENGINE TESTS.

(FOR TEST ON OPPOSITE PAGE.)

DISPLACEMENT TEST.

AVERAGE DISCHARGE.

To obtain Average Nozzle Pressure;
Sum Column "Min."............ 1,870
Subtract ½ sum of first and last figures.................... 85

1,785
Sum Column "¼"............ 1,791
" " "½"............ 1,795
" " "¾"............ 1,802

Divide by 80,.............) 7,173

Average Nozzle Reading.. 89.7
Correction from Gage Test Sheet........................ + 2.0

Average Nozzle Pressure. 91.7

From Discharge Tables for 1⅝" Nozzle:
92 lbs. gives .... 751 gallons.
90 " " .... 743 "

2 " " .... 8 "
1.7 lbs. gives .... 6.8 "
Then 91.7 lbs. = 749.8 gallons.

AVERAGE R. P. M.

Counter at 3.59................ 4,858
" " 3.39................ 7,870

Divide by 20..............) 6,488

Average R. P. M. = 324.4

ACTUAL DISPLACEMENT.

$$\frac{\text{Average Discharge}}{\text{Average R. P. M.}} = \frac{749.8}{324.4} = 2.311$$

NOMINAL DISPLACEMENT.

From Engine Displacement Table:
4½" Bore, 8" Stroke............ 2.455
1¼" Pump Rod................ .085

Nominal Displacement = 2.370

SLIP, IN PER CENT.

$$\frac{\text{Nom. Displacem't} - \text{Act. Displacem't}}{\text{Nominal Displacement}}$$

$$\frac{2.370 - 2.311}{2.370} = 3\%.$$

CAPACITY TEST.

AVERAGE R. P. M.

Same as for Displacement Test in this case.

GALLONS PER MINUTE.

Same as for Displacement Test in this case.

AVERAGES OF PRESSURES.

Steam:
Sum of Column............... 2,787
½ of first and last figures..... 133

Divide by 20...............) 2,654

Average Steam Reading.. 132.7

Water:
Sum of Column............. 3,065
½ of first and last figures... 142.5

Divided by 20...........) 2,922.5

Average Reading....... 146.1
Correction from Test of Gage and Test Sheet, for Gage No. 119............... − 1.0

Average Water Pressure 145.1

Suction:
Sum of Column............... 746
½ of first and last figures..... 35

Divide by 20..............) 711

Average Reading.......... 35.6
Correction from Test of Gage + 1.0

Average Suction Pressure 36.6

Net Pressure:
Average water pressure.... 145.1
Average suction pressure.. 36.6

Average net pressure.. 108.5

PERCENTAGE OF CAPACITY OBTAINED.

Reasonable capacity of Pumps based on 400 Ft. Piston Travel per Min. = 700 gals.
Obtained at Test......... 750 gals.
or 107% of Rating.

ENGINE DISPLACEMENT TABLE.

DOUBLE PUMPS.

Plunger Displacement. Gallons per Revolution.				Pump Rod Correction. Gallons per Revolution.			
Bore of Pump Inches.	Stroke in Inches.			Diameter of Pump Rods.	Stroke in Inches.		
	7	8	9		7	8	9
3 1/2	1.166	1.333	1.500	1 "	0.047	0.054	0.061
3 5/8	1.251	1.430	1.609	1 1/16	0.053	0.061	0.069
3 3/4	1.339	1.530	1.721	1 1/8	0.060	0.069	0.078
3 7/8	1.430	1.634	1.838	1 3/16	0.067	0.077	0.087
4	1.523	1.740	1.958	1 1/4	0.074	0.085	0.096
4 1/8	1.620	1.851	2.083	1 5/16	0.081	0.093	0.105
4 1/4	1.719	1.965	2.211	1 3/8	0.089	0.102	0.115
4 3/8	1.822	2.083	2.343	1 7/16	0.098	0.112	0.126
4 1/2	1.928	2.203	2.478	1 1/2	0.107	0.122	0.138
4 5/8	2.036	2.327	2.618	1 9/16	0.116	0.133	0.150
4 3/4	2.148	2.455	2.762	1 5/8	0.126	0.143	0.162
4 7/8	2.263	2.586	2.909	1 11/16	0.136	0.155	0.174
5	2.380	2.720	3.060	1 3/4	0.146	0.167	0.188
5 1/8	2.500	2.858	3.215				
5 1/4	2.624	2.999	3.374				
5 3/8	2.750	3.143	3.536				
5 1/2	2.880	3.291	3.702				
5 5/8	3.012	3.442	3.872				
5 3/4	3.147	3.597	4.047				
5 7/8	3.286	3.755	4.225				
6	3.427	3.917	4.407				

Subtract pump rod correction from plunger displacement to obtain correct displacement of engine.

For single-pump engines, use one-half of result obtained.

For single-acting pumps, do not subtract pump rod correction.

Example: Engine with 5¼-inch pump, 9-inch stroke and 1½-inch pump rod.

From Table above:

Displacement of Plunger = 3.374 gallons.
Correction for Rod = 0.138 gallons.

Nominal Displacement = 3.236 gallons.

Below is given a table for use when engines are worked at draft, either in actual service or in testing. A study of it will show that where a high lift is necessary, small suctions will restrict the capacity of an engine; the table indicates clearly what sizes are necessary under different conditions. The figures are based on the ability of the pumps to maintain a vacuum of 23 inches.

TABLE SHOWING MAXIMUM LIFT, IN FEET, WHEN DRAFTING VARIOUS QUANTITIES OF WATER WITH A FIRE ENGINE IN GOOD CONDITION.

Quantity of Water, Gallons per Minute.	Maximum Lift in Feet, Engine Drafting.					
	3" Suction.	3½" Suction.	4" Suction.	4½" Suction.	5" Suction.	
300	16	20	22½	24	24½	3 lengths of suction.
400	8½	17	20	22½	24	
500		12½	18½	20½	23	
600		7	15	19½	21	
700		4½	11	17	19½	
800			6½	14½	19	2 lengths of suction.
900			6	11½	17	
1,000				8	14½	
1,100				7½	12	
1,200				4	9½	
1,300					6½	
1,300	1 length of suction.				9½	

TABLE OF HOSE AND NOZZLES FOR TESTING ENGINES, USING SIAMESED LINES.

NOTE.—**Connect Lines to a Deluge Set Provided with a Short Lead of 3½- or 4-Inch Hose.** Use Only Smooth-Bore Nozzle and of the Diameter Given. By Regulating One of the Discharge Gates, Pressure can be Kept Nearly Constant and from Three-quarters to Full Capacity Obtained.

Size.	Bore of Pump.	Reasonable Capacity, Gallons per Minute.*	NUMBER AND LENGTH OF LINES AND SIZE OF NOZZLE NEEDED TO DELIVER THE REASONABLE CAPACITY AT THE DESIRED PRESSURE AT THE ENGINE.			
			100 Pounds.	120 Pounds.	140 Pounds.	160 Pounds.
Double Extra First	6"	1,100	2-50' lines of 3" or 3-50' lines of 2½" 2" Nozzle	2-100' lines of 3" or 3-100' lines of 2½" 2" Nozzle	2-150' lines of 3" or 3-150' lines of 2½" 2" Nozzle	2-200' lines of 3" or 3-200' lines of 2½" 2" Nozzle
Extra First	5¾"	1,000	2-50' lines of 2½" 2" Nozzle	1-100' line of 2½" and 1-50' line of 2½" 2" Nozzle	2-100' lines of 3" 2" Nozzle	2-150' lines of 2½" 2" Nozzle
First	5½"	900	2-50' lines of 2½" 1⅞" or 2" Nozzle	1-100' line of 2½" and 1-50' line of 2½" 1⅞" Nozzle	2-100' lines of 2½" 1⅞" Nozzle	2-150' lines of 2½" 1⅞" Nozzle
Second	5"	750	2-50' lines of 2½" 1¾" Nozzle	2-100' lines of 2½" 1¾" Nozzle	2-150' lines of 2½" 1¾" Nozzle	2-250' lines of 2½" 1¾" Nozzle
	4¾"	700	2-50' lines of 2½" 1⅝" Nozzle	2-100' lines of 2½" 1⅝" Nozzle	2-150' lines of 2½" 1⅝" Nozzle	2-250' lines of 2½" 1⅝" Nozzle
Third	4½" or 4¼"	600 or 550	1-100' line of 2½" and 1-150' line of 2½" 1⅝" Nozzle	1-100' line of 2½" and 1-150' line of 2½" 1½" Nozzle	1-100' line of 2½" and 1-200' line of 2½" 1½" Nozzle	2-250' lines of 2½" 1½" Nozzle
Fourth	4"	500	2-100' lines of 2½" 1⅜" Nozzle	2-200' lines of 2½" 1⅜" Nozzle	2-300' lines of 2½" 1⅜" Nozzle	1-100' line of 2½" 1⅜" Nozzle ‡
Fifth	3⅝"	400	2-100' lines of 2½" 1¼" Nozzle	1-100' line of 2½" 1¼" Nozzle ‡	1-150' line of 2½" 1¼" Nozzle ‡	1-200' line of 2½" 1¼" Nozzle ‡

*** Based on about 400' piston travel per minute. ‡ Single lines; deluge set omitted.**

NOTE.—If hose has not smoothest lining, shorter lines or a larger nozzle may be required; if hose is slightly larger than given on page 20, it may be necessary to use longer lines or a smaller nozzle.

TABLE OF NOZZLES FOR TESTING ENGINES, USING SINGLE 50-FOOT LINES OF HOSE.

NOTE.—Connect Line to Nozzle; Bring Engine to Speed and Regulate Discharge Gate; if Desired Pressure Cannot be Obtained, Use Nozzle ⅛" Smaller or Add Another Length of Hose.

Size.	Bore of Pump.	Reasonable Capacity, Gallons per Minute.*	Size of Nozzle Needed to Deliver the Reasonable Capacity at the Desired Pressure at the Engine.			
			100 Pounds.	120 Pounds.	140 Pounds.	160 Pounds.
			Single 50-foot Line of 3" hose			
First	5½"	900	2¼"	2¼" or 2"	2"	1⅞" or 1¾"
			Single 50-foot Line of 2½" hose			
Second	5" 4¾"	750 700	2" 1⅞"	1⅞" 1¾"	1⅞" 1¾"	1⅝" 1⅝"
Third	4½" 4¼"	600 550	1¾" or 1⅝" 1⅝"	1⅝" or 1½" 1½"	1½" 1⅜"	1⅜" 1⅜"
Fourth	4"	500	1½"	1⅜"	1⅜"	1¼"
Fifth	3⅝"	400	1¼"	1¼"	1⅛"	1⅛"

* Based on about 400′ piston travel per minute.

FIRE STREAM TABLES.

These tables are arranged to show the pressures required at the hydrant or fire engine, while stream is flowing, to maintain nozzle pressures given in the first columns, through various lengths of 2½-, 3- and 3½-inch rubber lined hose in single lines and two lines of 2½-inch hose siamesed.

Nozzle pressures of 40 to 60 pounds from 1⅛- and 1¼-inch nozzles will give streams which may be classed as good and which can be handled without special appliances; for deluge sets, turret pipes, etc., with 1½-inch and larger nozzles, 60 to 90 pounds nozzle pressure is desirable for effective fire fighting; the height, area and general character of the building are factors in determining at what pressure a stream may be considered good, as well as in determining whether a nozzle is of sufficient size to furnish an effective stream, nothing less than 1⅛-inch being considered as effective for outside work, except for fires in small buildings. In this connection it should be noted than a 1- or 1⅛-inch ring tip delivers a stream about ⅛ ineh smaller than the diameter of the tip.

The pressure at the hydrant or fire engine is that indicated by a gage attached to the hydrant or fire engine while the stream is flowing. The pressure at the nozzle is that indicated by a Pitot gage held in the stream.

The hydrant (or engine) pressures are obtained by adding to the nozzle pressure the friction loss in the hose, and also the small additional loss in the hydrant outlet or engine discharge.

Friction losses in hose are based on tests of best quality rubber-lined fire hose and are for 100-foot lengths measured without pressure applied. Diameters of hose, as measured under 75 pounds pressure, assumed as the average working condition, were as follows: For nominal 2½-inch, 2.575 or about 2 9/16 inches; for nominal 3-inch, 3.125 or 3⅛ inches; for nominal 3½-inch, 3.685 or about 3 11/16 inches.

The smoothness of the lining has a very considerable effect on the friction loss, some samples tested showing losses 50 per cent. in excess of those given. A slight variation in diameter also produces a marked difference in friction loss; in the case of 2½-inch hose, a variation of 1/16 inch in diameter will result in 10 per cent. difference in loss. If properly beveled 2½-inch couplings are used on 3-inch hose, the loss of pressure due to them will be less than 5 per cent. of that gained by the use of the larger hose. For instance, for a flow of 300 gallons per minute, the loss in 2½-inch hose will be about 21 pounds, in 3-inch hose with 3-inch couplings about 8 pounds, and in 3-inch with 2½-inch couplings about 8½ pounds.

For siamesed lines, an allowance was made for the loss in the siamese connection and for 20 feet of 3½-inch lead hose.

The pressures given are for the nozzle at the same elevation as the hydrant or engine discharge outlet. Add or subtract 1 pound to the pressure given for each 2 1/3 feet difference in elevation. The arrangement of the table allows a comparison to be readily made of the results obtainable with 3-inch hose and siamesed lines against single lines of 2½-inch hose.

An approximate formula for the friction loss in 2½-inch hose is as follows:

Pressure loss in each hundred feet, in pounds $= 2\,Q^2 + Q$, where Q is the quantity in gallons divide by 100. (For less than 100 gallons, pressure loss $= 2\,Q^2 + \frac{1}{2}\,Q$.)

The approximate figure for the friction loss in other sizes for the same quantity flowing can be obtained by dividing the friction loss in 2½-inch hose by the following factors:

Single Lines.

2¾"	3"	3½"	4"	4½"	5"
1.66	2.6	5.8	11.0	19.5	32.0

Siamesed Lines of Equal Length.

2-2½"	3-2½"	2-3"	3-3"	1-3" 1-2½"
3.6	7.75	9.35	20.4	6.1

TABLE OF NOZZLE FACTORS.

For use in obtaining discharge from smooth nozzle larger than those given in tables on pages 28 and 29, when nozzle pressure is obtained with a Pitot gage.

The discharge in gallons per minute is equal to the square root of the pressure multiplied by the factor.

Diameter of the nozzle in inches.	FACTORS.	
	For Fresh Water.	For Salt (sea) Water.
2	118.96	117.45
2¼	150.56	148.64
2½	185.88	183.50
2¾	224.91	222.05
3	267.66	264.25
3¼	314.13	310.13
3½	364.32	359.68
3¾	418.23	412.99
4	475.85	469.79
4¼	537.19	530.35
4½	602.25	594.58
4¾	671.02	662.48
5	743.51	734.03
6	1,070.64	1,057.00

For any size nozzles, the discharge, for fresh water, can be determined by the following formula:

Gallons per minute $= 29.83\ c\ d^2 \sqrt{p}$.

Where d = diameter of nozzle in inches, measured to 1/1000 of an inch.

p = pressure recorded on Pitot gage in pounds.

c = a constant, varying from 0.990 for 1-inch nozzle to 0.997 for 6-inch nozzle.

For ordinary use, the formula can be reduced to:

Gallons per minute $= 29.7\ d^2 \sqrt{p}$.

FORMULA FOR OBTAINING APPROXIMATE NOZZLE OR ENGINE PRESSURES, LENGTH OF LINE AND SIZE OF NOZZLE BEING GIVEN.

$$\text{Nozzle Pressure in pounds} = \frac{\text{Engine Pressure}}{1.1 + K L}$$

$$\text{Engine Pressure in pounds} = \text{Nozzle Pressure } (1.1 + K L).$$

L = Number of 50-foot lengths of hose.

K = Constant, varying with size of nozzle and hose. See Table following.

Size Nozzle, Inches.	K FOR					
	Single Line 2½" Hose.	Single Line 3" Hose.	Single Line 3½" Hose.	Two 2½" Lines Siamesed. *	Two 3" Lines Siamesed. *	3 Lines 2½" Hose. *
1	.105	.038	....	.025	....	....
1⅛	.167	.062	....	.043	....	....
1¼	.248	.092	.039	.066	.023	.028
1⅜	.341	.137	.059	.096	.034	.043
1½	.505	.193	.084	.135	.051	.061
1⅝	.680	.266	.113	.184	.068	.084
1¾	.907	.351	.152	.242	.093	.115
2	1.550	.605	.250	.418	.157	.190

* Allowance is made for loss in deluge set; these values will also give approximately correct figures for turret nozzles and water tower, except that in the latter, pressure equal to 0.434 times the height of tower must be subtracted from the engine pressure, before solving for nozzle pressure.

EFFECTIVE REACH OF FIRE STREAMS.

SHOWING THE DISTANCE IN FEET FROM THE NOZZLE AT WHICH STREAMS WILL DO EFFECTIVE WORK WITH A MODERATE WIND BLOWING. WITH A STRONG WIND THE REACH IS GREATLY REDUCED.

Pressure at Nozzle.	Size of Nozzle.									
	1-Inch.		1⅛-Inch		1¼-Inch.		1⅜-Inch.		1½-Inch.	
	Vertical Distance, Feet.	Horizontal Distance, Feet.	Vertical Distance, Feet.	Horizontal Distance, Feet.	Vertical Distance, Feet.	Horizontal Distance, Feet.	Vertical Distance, Feet.	Horizontal Distance, Feet.	Vertical Distance, Feet.	Horizontal Distance, Feet.
20	35	37	36	38	36	39	36	40	37	42
25	43	42	44	44	45	46	45	47	46	49
30	51	47	52	50	52	52	53	54	54	56
35	58	51	59	54	59	58	60	59	62	62
40	64	55	65	59	65	62	66	64	69	66
45	69	58	70	63	70	66	72	68	74	71
50	73	61	75	66	75	69	77	72	79	75
55	76	64	79	69	80	72	81	75	83	78
60	79	67	83	72	84	75	85	77	87	80
65	82	70	86	75	87	78	88	79	90	82
70	85	72	88	77	90	80	91	82	92	84
75	87	74	90	79	92	82	93	84	94	86
80	89	76	92	81	94	84	95	86	96	88
85	91	78	94	83	96	87	97	88	98	90
90	92	80	96	85	98	89	99	90	100	92

NOTE.—Nozzle pressures are as indicated by Pitot tube. The horizontal and vertical distances are based on experiments by Mr. John R. Freeman, *Transactions*, Am. Soc. C. E., Vol. XXI.

FRICTION LOSS IN FIRE HOSE.

BASED ON TESTS OF BEST QUALITY RUBBER LINED FIRE HOSE.*

Flow, Gallons per Minute.	Pressure Loss in Each 100 Feet of Hose, Pounds per Sq. Inch.				Flow, Gallons per Minute.	Pressure Loss in Each 100 Feet of Hose, Pounds per Sq. Inch.		
	2½" Hose.	3" Hose.	3½" Hose.	2 Lines of 2½" Siamesed.		3" Hose.	3½" Hose.	2 Lines of 2½" Siamesed.
140	5.2	2.0	0.9	1.4	525	23.2	10.5	16.6
160	6.6	2.6	1.2	1.9	550	25.2	11.4	18.1
180	8.3	3.2	1.5	2.3	575	27.5	12.4	19.0
200	10.1	3.9	1.8	2.8	600	29.9	13.4	21.2
220	12.0	4.2	2.1	3.3	625	32.0	14.4	23.0
240	14.1	5.4	2.5	3.9	650	34.5	15.5	24.8
260	16.4	6.3	2.9	4.5	675	37.0	16.6	26.5
280	18.7	7.2	3.3	5.2	700	39.5	17.7	28.3
300	21.2	8.2	3.7	5.9	725	42.3	18.9	30.2
320	23.8	9.3	4.2	6.6	750	45.0	20.1	32.2
340	26.9	10.5	4.7	7.4	775	47.8	21.4	34.2
360	30.0	11.5	5.2	8.3	800	50.5	22.7	36.2
380	33.0	12.8	5.8	9.2	825	53.5	24.0	38.4
400	36.2	14.1	6.3	10.1	850	56.5	25.4	40.7
425	40.8	15.7	7.0	11.3	875	59.7	26.8	43.1
450	45.2	17.5	7.9	12.5	900	63.0	28.2	45.2
475	50.0	19.3	8.7	13.8	1,000	76.5	34.3	55.0
500	55.0	21.2	9.5	15.2	1,100	91.5	41.0	65.5

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*Rough rubber lining is liable to increase the losses given in the table as much as 50 per cent.

DISCHARGE TABLE FOR SMOOTH NOZZLES.

NOZZLE PRESSURE MEASURED BY PITOT GAGE.

Nozzle Pressure in lbs. per sq. inch.	Nozzle Diam. in Inches. 1	1⅛	1¼	1⅜	1½	Nozzle Pressure in lbs. per sq. inch.	Nozzle Diam. in Inches. 1	1⅛	1¼	1⅜	1½
	Gallons per minute.						Gallons per Minute.				
5	66	84	103	125	149	60	229	290	357	434	517
6	72	92	113	137	163	62	233	295	363	441	525
7	78	99	122	148	176	64	237	299	369	448	533
8	84	106	131	158	188	66	240	304	375	455	542
9	89	112	139	168	200	68	244	308	381	462	550
10	93	118	146	177	211	70	247	313	386	469	558
12	102	130	160	194	231	72	251	318	391	475	566
14	110	140	173	210	249	74	254	322	397	482	574
16	118	150	185	224	267	76	258	326	402	488	582
18	125	159	196	237	283	78	261	330	407	494	589
20	132	167	206	250	298	80	264	335	413	500	596
22	139	175	216	263	313	82	268	339	418	507	604
24	145	183	226	275	327	84	271	343	423	513	611
26	151	191	235	286	340	86	274	347	428	519	618
28	157	198	244	297	353	88	277	351	433	525	626
30	162	205	253	307	365	90	280	355	438	531	633
32	167	212	261	317	377	92	283	359	443	537	640
34	172	218	269	327	389	94	286	363	447	543	647
36	177	224	277	336	400	96	289	367	452	549	654
38	182	231	285	345	411	98	292	371	456	554	660
40	187	237	292	354	422	100	295	374	461	560	667
42	192	243	299	363	432	105	303	383	473	574	683
44	196	248	306	372	442	110	310	392	484	588	699
46	200	254	313	380	452	115	317	401	495	600	715
48	205	259	320	388	462	120	324	410	505	613	730
50	209	265	326	396	472	125	331	418	516	626	745
52	213	270	333	404	481	130	337	427	526	638	760
54	217	275	339	412	490	135	343	435	536	650	775
56	221	280	345	419	499	140	350	443	546	662	789
58	225	285	351	426	508	145	356	450	556	674	803
60	229	290	357	434	517	150	362	458	565	686	817

Assumed coefficient of discharge = .99 .99 .99 .99¼ .99½

NOTE.—Coefficients of discharge are based on experiments by Mr. John R. Freeman, Transactions Am. Soc. C. E., Vols. XXI and XXIV.

DISCHARGE TABLE FOR SMOOTH NOZZLES.

Gal

P

Mi

1
1
1
1
2
2

54	576	668	769	873	1103	135	910	1056	1218	1383	17
56	586	680	782	889	1129	140	927	1076	1235	1407	17
58	596	692	796	905	1149	145	944	1095	1257	1432	181
60	607	704	810	920	1168	150	960	1114	1279	1456	184

Assumed coefficient of discharge = .995 .995 .996 .997 .99

DISCHARGE TABLE FOR SMOOTH NOZZLES.

	213	270	[illegible]	[illegible]	481	130	337	427	530	638	760
	217	275	339	412	490	135	343	435	536	650	775
[illegible]	221	280	345	419	499	140	350	443	546	663	789
58	225	285	351	426	508	145	356	450	556	674	803
60	229	290	[illegible]	[illegible]	517	150	[illegible]	458	565	686	817

Assumed coefficient of discharge ⇒ .99 .99 .99 .99¼ .99½

NOTE.—Coefficients of discharge are based on experiments by Mr. John R. Freeman, *Transactions Am. Soc. C. E.*, Vols. XXI and XXIV.

DISCHARGE TABLE FOR SMOOTH NOZZLES.

Gall

2(

Mi

1

1

1

1

2

2

54	576	668	769	873	1108	135	910	1058	1218	1383	1750
56	586	680	783	889	1129	140	927	1076	1238	1407	1780
58	596	692	796	905	1149	145	944	1095	1257	1432	1812
60	607	704	810	920	1168	150	960	1114	1279	1456	1843

Assumed coefficient of discharge = .995 .995 .996 .997 .997

1-INCH SMOOTH NOZZLE.—

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR MAINTAIN NOZZLE PRESSURES GIVEN LENGTHS OF BEST QUALITY							
		Single 2½-inch Lines.							
		100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	700 Feet	800 Feet.
20	132	25	30	35	39	44	49	53	58
25	148	31	37	43	49	55	60	66	72
30	162	38	44	51	58	65	72	78	85
35	175	44	52	59	67	75	83	91	98
40	187	50	59	68	77	86	94	103	112
45	198	56	66	76	86	96	106	115	125
50	209	62	73	84	95	106	117	128	139
55	219	68	80	92	104	116	128	140	152
60	229	75	88	101	114	127	140	153	166
65	238	81	95	109	123	137	151	165	179
70	247	87	102	117	132	147	162	177	192
75	256	93	109	125	141	157	173	189	205
80	264	99	116	133	150	167	183	200	217
85	272	105	123	141	159	177	195	212	230
90	280	111	130	149	167	186	205	224	243
95	287	117	137	157	177	196	216	236	256
100	295	123	144	165	185	206	227	247	268

FIRE ENGINE, WHILE STREAM IS FLOWING, TO
IN FIRST COLUMN, THROUGH VARIOUS
2½- AND 3-INCH RUBBER LINED HOSE.

		Single 3-inch Lines.				Two 2½-inch Lines Siamesed.			Nozzle Pressure Indicated by Pitot Gage.
1,000 Feet.	1,200 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,000 Feet.	1,500 Feet.	2,000 Feet.	
68	77	35	39	42	48	33	40	46	20
84	95	43	48	52	59	41	49	57	25
99	112	52	57	62	70	49	59	68	30
114	130	60	66	72	81	57	68	79	35
130	148	68	75	82	92	65	78	90	40
145	165	77	84	92	103	72	86	99	45
160	182	85	93	102	114	80	95	110	50
175	199	93	102	112	125	88	105	121	55
192	218	102	112	122	137	96	114	132	60
207	235	110	121	131	148	103	122	141	65
222	252	118	130	141	159	111	132	152	70
237	269	127	139	151	170	120	142	164	75
251	285	135	148	161	181	128	151	175	80
266	302	143	156	170	191	135	159	184	85
280	...	151	165	180	202	143	169	195	90
295	...	158	173	189	211	150	177	204	95
310	.....	167	183	199	223	157	186	215	100

1 1/8-INCH SMOOTH NOZZLE.—

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE NOZZLE PRESSURES GIVEN IN FIRST QUALITY 2½- AND									
		Single 2½-inch Lines.									
		100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	700 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.
20	167	28	35	42	49	56	64	71	78	92	107
25	187	35	44	53	62	71	79	88	97	115	133
30	205	42	52	63	73	84	95	105	116	137	158
35	221	49	61	73	85	97	110	122	134	158	183
40	237	55	69	83	96	110	124	138	151	179	206
45	251	62	77	93	108	123	139	154	169	200	230
50	265	69	86	103	120	137	154	171	188	222	256
55	277	76	94	112	131	149	168	186	204	241	278
60	290	83	103	123	143	163	183	203	223	263	304
65	301	89	111	132	154	175	197	218	240	283	326
70	313	96	119	142	165	188	211	234	257	303	....
75	324	103	128	152	177	202	227	252	276	325	....
80	335	110	136	162	188	215	241	267	294	....	....
85	345	116	144	171	199	226	254	282	309	....	....
90	355	123	152	181	210	240	269	298	327	....	....
95	365	130	160	191	222	252	283	314	....	....	....
100	374	136	168	201	233	265	297	329	....	....	....

ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN COLUMN, THROUGH VARIOUS LENGTHS OF BEST 3-INCH RUBBER LINED HOSE.

Single 3-inch Lines.							Two 2½-inch Lines Siamesed.					Nozzle Pressure Indicated by Pitot Gage.
400 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
32	37	43	48	54	62	71	38	42	46	53	60	20
40	46	53	60	67	77	87	45	50	55	63	70	25
47	55	63	71	79	91	103	53	59	65	74	82	30
55	65	74	83	93	107	121	62	69	76	86	96	35
63	73	84	95	105	121	137	70	78	86	97	108	40
70	82	94	106	118	135	153	79	87	95	108	121	45
78	91	104	117	130	150	169	88	98	107	121	135	50
86	100	114	128	142	164	185	96	107	117	132	147	55
93	109	124	139	155	178	201	105	116	127	143	160	60
101	117	134	151	167	192	217	114	126	138	156	174	65
108	126	144	162	180	206	233	122	135	148	167	186	70
116	135	154	173	192	221	249	130	144	157	178	198	75
124	144	165	185	206	236	267	138	153	167	189	210	80
131	153	174	195	217	249	281	147	163	178	201	224	85
139	161	184	207	229	263	297	156	172	188	212	237	90
146	170	194	218	242	277	313	164	181	198	224	249	95
154	178	203	228	253	290	....	172	190	208	235	261	100

1 1/4-INCH SMOOTH NOZZLE.—

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE PRESSURES GIVEN IN FIRST COLUMN, 2½- AND 3-INCH									
		Single 2½-inch Lines.									
		100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	700 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.
20	206	32	42	53	64	75	85	96	107	128	149
25	230	40	53	66	79	92	105	118	131	158	184
30	253	48	63	79	95	110	126	142	157	189	220
35	273	55	73	91	109	127	145	163	181	217	253
40	292	63	83	104	124	144	165	185	206	246	287
45	309	70	93	116	138	161	183	206	229	274	319
50	326	78	103	128	153	178	203	228	253	303	....
55	342	86	113	140	167	194	222	249	276	330	....
60	357	93	123	152	182	211	241	270	300	....	....
65	372	101	133	164	196	228	260	292	323	....	....
70	386	108	142	176	210	244	278	312	....	....	....
75	399	116	152	188	224	261	297	333	....	....	....
80	413	124	163	201	240	279	318	....	....	....	....
85	425	131	172	213	254	295	....	....	....	....	....
90	438	139	182	225	269	312	....	....	....	....	...
95	449	146	191	236	282	327	....	....	....	....	....
100	461	153	201	248	295	....	....	....	....	....	....

2 1/2- AND 3-INCH HOSE.

ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN NOZZLE THROUGH VARIOUS LENGTHS OF BEST QUALITY RUBBER LINED HOSE.

Single 3-inch Lines.							Two 2½-inch Lines Siamesed.						Nozzle Pressure Indicated by Pitot Gage.
400 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
37	46	54	62	70	83	95	39	45	51	57	67	76	**20**
47	57	67	77	87	102	117	48	55	62	70	80	91	**25**
56	68	81	93	105	123	142	57	66	74	83	96	109	**30**
65	79	92	106	120	141	161	66	76	86	95	110	125	**35**
74	89	105	120	136	159	183	75	87	99	110	127	144	**40**
83	100	117	135	152	178	204	84	96	109	121	140	158	**45**
91	111	130	149	168	197	226	93	107	121	135	155	176	**50**
100	121	142	163	184	216	247	102	117	132	147	169	192	**55**
109	132	155	178	201	235	270	111	128	144	160	185	210	**60**
118	143	167	192	217	254	291	120	137	155	173	199	225	**65**
127	154	180	206	233	272	....	129	147	166	185	213	241	**70**
136	164	192	220	248	290	....	137	157	177	197	227	257	**75**
145	175	205	235	265	....	....	147	169	190	212	244	276	**80**
153	184	216	247	279	....	....	156	179	201	224	258	292	**85**
162	195	228	261	295	....	....	165	189	213	237	273	309	**90**
170	205	240	275	....	....	....	173	198	223	248	286	323	**95**
179	215	252	288	....	....	....	182	208	235	261	300	....	**100**

1 3/8-INCH SMOOTH NOZZLE.—

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE NOZZLE PRESSURES GIVEN IN FIRST QUALITY 2½- AND									
		Single 2½-inch Lines.									
		100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	700 Feet.	800 Feet.	200 Feet.	400 Feet.
20	250	37	52	68	83	98	113	128	144	34	45
25	280	46	64	83	102	121	139	158	177	41	56
30	307	55	77	99	121	144	166	188	210	50	67
35	331	64	89	115	140	166	191	217	242	58	78
40	354	73	102	131	160	189	218	247	276	67	89
45	376	81	114	146	178	211	243	275	307	74	99
50	396	90	125	161	196	222	257	293	328	82	109
55	415	99	137	176	215	254	292	331	....	90	121
60	434	107	149	191	233	276	318	....	....	98	131
65	451	116	161	206	251	297	....	....	....	106	141
70	469	125	173	222	270	319	....	....	....	114	152
75	485	134	185	237	289	....	....	....	....	122	162
80	500	142	196	251	305	....	....	....	....	130	172
85	516	151	209	267	325	....	....	....	....	138	183
90	531	159	220	281	....	....	....	....	....	146	194
95	546	168	232	297	....	....	....	....	....	153	203
100	560	177	244	312	....	....	....	....	....	162	215

ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN COLUMN, THROUGH VARIOUS LENGTHS OF BEST 3-INCH RUBBER LINED HOSE.

Single 3-inch Lines.					Two 2½-inch Lines Siamesed.							Nozzle Pressure Indicated by Pitot Gage.
600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	400 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
57	68	80	92	109	37	46	54	63	71	84	96	**20**
70	85	99	113	135	46	57	67	78	88	104	119	**25**
84	101	118	135	161	56	68	81	93	106	124	143	**30**
97	117	137	157	187	65	80	94	108	122	143	165	**35**
112	134	157	180	214	74	90	106	122	138	162	186	**40**
125	150	175	200	238	83	101	119	137	155	182	209	**45**
137	164	192	220	267	92	111	131	151	171	201	230	**50**
151	182	212	242	288	100	122	144	165	187	219	252	**55**
163	196	229	262	....	109	133	156	180	203	238	273	**60**
177	212	247	282	....	118	143	168	194	219	257	294	**65**
189	227	265	303	....	128	155	182	209	236	277	317	**70**
203	243	283	....	....	137	165	194	223	252	295	....	**75**
215	257	300	....	....	145	175	206	236	266	312	....	**80**
229	274	....	....	....	153	186	218	250	282	331	....	**85**
241	289	....	....	....	162	196	230	264	298	....	....	**90**
254	304	....	....	....	170	206	241	277	313	....	....	**95**
267	....	....	....	....	179	217	254	291	329	....	....	**100**

1 1/2-INCH SMOOTH NOZZLE.—

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE NOZZLE PRESSURES GIVEN IN FIRST QUALITY 2½- AND										
		Single 2½-inch Lines.								Single		
		100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	700 Feet.	800 Feet.	200 Feet.	400 Feet.	600 Feet.
20	298	44	65	86	107	128	149	170	191	39	55	71
25	333	54	80	106	132	158	184	210	236	48	68	88
30	365	65	95	126	157	188	219	250	280	58	81	105
35	394	75	110	145	181	216	251	287	322	67	94	122
40	422	85	126	166	206	246	286	327	....	76	107	139
45	447	96	141	185	230	275	320	....	....	85	120	155
50	472	106	155	205	254	304	....	....	....	95	133	171
55	494	116	170	224	278	332	....	....	....	104	145	187
60	517	126	184	242	301	....	....	....	....	113	158	203
65	537	136	198	261	324	....	....	....	....	122	170	218
70	558	146	213	281	....	....	....	....	....	131	183	235
75	578	156	228	299	....	....	....	....	....	140	196	251
80	596	166	242	318	....	....	....	....	....	149	208	267
85	614	176	257	337	....	....	....	....	....	158	220	282
90	633	187	272	....	....	....	....	....	....	167	233	298
95	650	197	286	....	....	....	....	....	....	176	245	314
100	667	207	300	....	....	....	....	....	....	185	257	...

ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN COLUMN, THROUGH VARIOUS LENGTHS OF BEST 3-INCH RUBBER LINED HOSE.

3-inch Lines.				Two 2½-inch Lines Siamesed.								Nozzle Pressure Indicated by Pitot Gage.
800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	200 Feet.	400 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
87	104	120	144	33	45	56	68	79	91	108	126	20
108	128	148	178	41	56	70	84	99	113	135	156	25
129	153	177	212	49	66	83	100	117	134	160	185	30
149	177	204	245	57	77	96	116	135	155	184	214	35
170	201	232	279	65	88	110	132	155	177	211	244	40
189	224	258	....	73	97	122	146	171	196	233	269	45
209	247	286	....	81	108	136	163	190	218	259	300	50
228	270	....	....	88	118	148	178	208	237	282	327	55
248	293	....	....	96	128	161	193	225	257	305	....	60
267	....	....	....	104	139	174	208	243	278	....	....	65
287	....	....	....	112	149	186	223	261	298	....	....	70
307	....	....	....	120	160	199	239	279	319	....	....	75
....	....	....	....	127	170	212	254	296	....	....	....	80
....	....	....	....	135	179	224	268	313	....	....	....	85
....	....	....	....	143	190	237	284	....	....	....	....	90
....	....	....	....	152	201	251	301	....	....	....	....	95
....	....	....	....	160	212	264	316	....	....	....	....	100

1 5/8-INCH SMOOTH NOZZLE.—

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	Pressures Required at Hydrant or Fire Nozzle Pressures given in First Quality 2½- and									
		Single 2½-inch Lines.						Single 3-inch			
		100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	200 Feet.	400 Feet.	600 Feet.	800 Feet.
20	350	52	80	108	136	165	193	46	68	90	112
25	392	65	100	135	170	205	240	57	84	111	128
30	429	77	118	160	201	242	284	68	100	132	164
35	463	89	136	184	231	279	326	78	115	152	189
40	496	101	155	208	262	316	....	89	131	173	215
45	525	113	173	233	293	....	....	100	146	193	239
50	554	125	192	258	324	....	....	111	162	214	265
55	581	137	210	282	....	....	....	121	178	234	290
60	607	149	228	306	....	....	....	132	193	254	....
65	631	162	246	330	....	....	....	143	209	275	....
70	655	173	263	....	....	....	....	153	223	294	....
75	678	184	281	....	....	....	....	163	237	312	....
80	700	197	299	....	....	....	....	174	253	....	....
85	722	209	317	....	....	....	....	184	269	....	....
90	743	220	....	....	....	....	....	195	284	....	....
95	763	232	....	....	....	....	....	205	299	....	....
100	783	244	....	....	....	....	....	216	314	....	....

2 1/2- AND 3-INCH HOSE.

ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN COLUMN, THROUGH VARIOUS LENGTHS OF BEST 3-INCH RUBBER LINED HOSE.

Lines.		Two 2½-inch Lines Siamesed.								Nozzle Pressure Indicated by Pitot Gage.
1,000 Feet.	1,200 Feet.	200 Feet.	400 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
134	156	37	53	68	84	100	115	139	162	20
165	192	47	66	85	104	123	143	171	200	25
196	228	56	79	102	125	148	171	205	240	30
226	263	65	91	117	144	170	197	236	276	35
257	299	74	104	134	164	194	224	269	314	40
286	....	82	116	149	182	215	248	298	....	45
....	....	91	128	165	202	239	275	331	....	50
....	....	100	140	181	221	261	301	....	....	55
....	....	109	153	196	240	283	327	....	....	60
....	....	118	164	211	258	305	....	....	....	65
....	....	126	176	226	276	326	....	....	....	70
....	....	135	189	242	295	....	....	....	....	75
....	....	144	201	258	314	....	....	....	....	80
....	....	153	213	273	....	....	....	....	....	85
....	....	162	225	289	....	....	....	....	....	90
....	....	170	237	303	....	....	....	....	....	95
....	....	179	249	319	....	...	....	....	....	100

1 3/4-INCH SMOOTH NOZZLE.—

Nozzle Pressure Indicated by Pitot Gage.	Discharge Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE NOZZLE PRESSURES GIVEN IN FIRST QUALITY 2½- AND									
		Single 2½-in. Lines.				Single 3-inch					
		100 Feet.	200 Feet.	300 Feet.	400 Feet.	100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.
20	407	63	100	138	175	40	55	71	86	101	116
25	455	77	123	169	215	49	67	84	102	120	138
30	498	91	145	199	253	58	79	100	121	142	163
35	538	106	169	231	294	68	92	117	141	166	190
40	575	120	191	262	333	77	104	132	159	187	215
45	609	135	215	294	....	87	118	149	180	211	241
50	643	150	237	325	....	96	130	164	199	233	267
55	674	164	259	....	....	105	142	179	216	254	291
60	704	177	280	....	....	114	154	194	234	274	314
65	732	191	302	...	....	123	166	209	252	296	....
70	761	206	325	....	....	133	180	227	273	....	......
75	787	220	....	....	....	143	192	242	291	....	....
80	813	234	....	....	...	152	204	257	309	....	....
85	838	247	...	...	....	160	215	270	....	....	....
90	862	261	...	....	....	169	228	286	....	....	....
95	885	274	....	....	....	178	240	301	....	....	....
100	909	....	....	....	....	188	253	317	....	...	....

ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN COLUMN, THROUGH VARIOUS LENGTHS OF BEST 3-INCH RUBBER LINED HOSE.											Nozzle Pressure Indicated by Pitot Gage.
Lines.		Two 2½-inch Lines Siamesed.									
800 Feet.	1,000 Feet.	100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	
147	177	33	43	53	64	74	84	105	125	146	20
173	209	40	53	65	78	91	103	128	154	179	25
205	247	49	64	79	94	110	125	155	185	215	30
239	288	56	74	91	109	126	143	178	213	248	35
270	325	64	84	103	123	143	162	201	241	280	40
303	....	73	95	117	139	161	183	227	271	315	45
....	....	80	104	128	152	177	201	249	297	....	50
....	....	88	114	140	167	193	219	272	324	....	55
....	....	96	125	153	182	210	239	296	....	....	60
....	....	104	134	165	195	226	257	318	....	....	65
....	....	111	144	177	210	243	275	....	....	....	70
...	....	118	153	188	223	258	293	....	....	....	75
....	....	127	164	201	239	276	313	....	...	....	80
....	....	135	174	214	253	293	....	....	....	....	85
....	....	142	183	225	266	308	....	....	....	....	90
....	....	150	194	237	281	...	....	....	....	....	95
....	....	158	204	250	296	....	....	....	....	....	100

2-INCH SMOOTH NOZZLE.—

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE NOZZLE PRESSURES GIVEN IN FIRST QUALITY 2½- AND							
		Single 2½-inch Lines.			Single 3-inch Lines.				
		100 Feet.	200 Feet.	300 Feet.	100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.
20	532	90	152	214	52	76	100	124	148
25	594	111	187	263	65	94	123	152	182
30	651	132	222	312	77	112	147	181	216
35	703	152	255	.....	89	129	169	209	249
40	752	173	290	.....	102	147	193	238	283
45	797	193	323	....	113	163	213	263	314
50	841	214	.....	.....	126	182	237	293	.....
55	881	.....	.....	.....	138	199	260	321	.....
60	920	.....	.....	.....	150	216	282	.....	.....
65	958	.....	.....	.....	162	233	304	.....	.....
70	994	.....	.....	.....	175	251	327	.....	.....
75	1,029	.....	.....	.....	187	268	.....	.....	.....
80	1,063	....	.....	.....	199	285	.....	.....	.....
85	1,095	.....	.....	.....	211	302	.....	.....	.....
90	1,128	.....	.....	.....	223	319	.....	.....	.....
95	1,158	....	.....	.....	235	335	.....	....	....
100	1,189	.....	.....	....	247	.....	.....	.....	.....

ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN COLUMN, THROUGH VARIOUS LENGTHS OF BEST 3-INCH RUBBER LINED HOSE.

		Two 2½-inch Lines Siamesed.								
600 Feet.	800 Feet.	100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	800 Feet.	1,000 Feet.	Nozzle Pressure Indicated by Pitot Gage.
172	220	41	58	75	92	110	127	161	195	20
211	270	51	72	93	114	135	156	198	240	25
251	321	61	86	110	135	160	185	234	284	30
289	.....	71	100	128	157	186	214	271	329	35
.....	.....	81	113	146	178	211	243	308	.....	40
.....	.....	90	126	162	198	234	270	.....	.....	45
.....	.....	100	140	180	220	260	300	.....	.....	50
.....	.....	110	153	197	240	284	.....	.....	.....	55
.....	.....	119	166	213	260	308	.....	.....	.....	60
.....	.....	129	180	230	281	.....	.....	.....	.....	65
.....	.....	139	193	248	302	.....	.....	.....	.....	70
.....	.....	148	206	264	322	.....	.....	.....	.....	75
.....	.....	158	219	280	.....	.....	.....	.....	.....	80
.....	.....	167	232	297	.....	.....	.....	.....	.....	85
.....	.....	177	245	314	.....	.....	.....	.....	.....	90
.....	.....	186	258	.....	.....	.....	.....	.....	.....	95
.....	.....	196	272	.....	.....	.....	.....	.....	.....	100

1 1/4-INCH SMOOTH NOZZLE.—3 1/2-INCH HOSE.

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN NOZZLE PRESSURES GIVEN IN FIRST COLUMN, THROUGH VARIOUS LENGTHS OF BEST QUALITY 3½-INCH RUBBER LINED HOSE.								Nozzle Pressure Indicated by Pitot Gage.
		600 Feet.	700 Feet.	800 Feet.	900 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
20	206	32	34	36	37	39	43	49	55	**20**
25	230	39	42	44	46	48	53	60	67	**25**
30	253	47	49	52	55	58	63	71	79	**30**
35	273	54	57	60	64	67	73	82	91	**35**
40	292	62	65	69	72	76	83	93	104	**40**
45	309	69	73	77	81	85	93	104	116	**45**
50	326	77	81	85	90	94	102	115	128	**50**
55	342	84	89	94	99	103	112	126	141	**55**
60	357	92	97	102	107	112	122	137	153	**60**
65	372	99	105	110	116	121	132	149	165	**65**
70	386	107	113	118	124	130	142	160	177	**70**
75	399	114	120	127	133	139	152	171	190	**75**
80	413	122	128	135	142	148	162	182	202	**80**
85	425	128	135	142	149	156	170	191	212	**85**
90	438	136	143	151	158	165	180	202	225	**90**
95	449	143	151	159	167	175	190	214	237	**95**
100	461	151	159	167	175	184	200	225	249	**100**

1 3/8-INCH SMOOTH NOZZLE.—3 1/2-INCH HOSE.

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN NOZZLE PRESSURES GIVEN IN FIRST COLUMN, THROUGH VARIOUS LENGTHS OF BEST QUALITY 3½-INCH RUBBER LINED HOSE.									Nozzle Pressure Indicated by Pitot Gage.
		400 Feet.	500 Feet.	600 Feet.	700 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
20	250	31	34	36	39	41	47	52	60	67	**20**
25	280	39	42	45	49	52	59	65	75	85	**25**
30	307	46	50	54	58	62	70	78	89	101	**30**
35	331	54	58	63	67	72	81	90	103	117	**35**
40	354	61	66	71	76	81	91	101	116	131	**40**
45	376	69	74	80	85	91	102	113	130	147	**45**
50	396	76	82	88	95	101	113	126	144	163	**50**
55	415	84	90	97	104	111	124	138	158	179	**55**
60	434	91	98	106	113	121	135	150	172	195	**60**
65	451	98	106	114	122	130	146	161	185	209	**65**
70	469	106	114	123	131	140	157	174	199	225	**70**
75	485	113	122	131	140	149	167	185	212	239	**75**
80	500	120	130	140	149	159	178	197	226	255	**80**
85	516	127	138	148	158	168	188	208	239	269	**85**
90	531	135	146	156	167	178	199	221	253	285	**90**
95	546	142	153	165	176	187	209	232	266	299	**95**
100	560	150	161	173	185	197	220	244	279	315	**100**

1 1/2-INCH SMOOTH NOZZLE.—3 1/2-INCH HOSE.

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN NOZZLE PRESSURES GIVEN IN FIRST COLUMN, THROUGH VARIOUS LENGTHS OF BEST QUALITY 3½-INCH RUBBER LINED HOSE.								Nozzle Pressure Indicated by Pitot Gage.
		200 Feet.	400 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
20	298	28	36	43	50	58	65	76	87	20
25	333	35	44	53	62	71	80	93	107	25
30	365	42	53	63	74	85	96	112	128	30
35	394	49	61	73	86	98	111	129	148	35
40	422	55	69	83	97	111	125	146	167	40
45	447	62	78	93	109	125	140	164	187	45
50	472	69	86	103	121	138	155	181	207	50
55	494	76	94	113	132	151	170	198	226	55
60	517	82	102	123	143	163	183	214	244	60
65	537	89	111	133	154	176	198	231	263	65
70	558	96	119	143	166	189	213	248	283	70
75	578	103	128	153	178	203	228	265	303	75
80	596	109	136	162	188	215	241	281	....	80
85	614	116	144	172	200	228	256	298	....	85
90	633	123	152	182	211	241	271	....	....	90
95	650	129	160	191	222	253	284	....	....	95
100	667	136	168	201	233	265	298	....	....	100

1 5/8-INCH SMOOTH NOZZLE.—3 1/2-INCH HOSE.

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN NOZZLE PRESSURES GIVEN IN FIRST COLUMN, THROUGH VARIOUS LENGTHS OF BEST QUALITY 3½-INCH RUBBER LINED HOSE.								Nozzle Pressure Indicated by Pitot Gage.
		200 Feet.	400 Feet.	600 Feet.	800 Feet.	1,000 Feet.	1,200 Feet.	1,500 Feet.	1,800 Feet.	
20	350	31	41	50	60	70	80	94	109	20
25	392	38	51	63	75	87	99	118	136	25
30	429	46	60	75	89	103	118	139	161	30
35	463	53	70	86	103	120	136	161	186	35
40	496	61	79	98	117	136	155	183	211	40
45	525	68	89	110	131	152	173	205	236	45
50	554	76	99	122	145	168	192	226	261	50
55	581	83	108	133	158	184	209	247	284	55
60	607	90	117	144	172	199	226	267	308	60
65	631	97	127	156	186	215	244	289	....	65
70	655	105	136	167	199	230	262	309	....	70
75	678	112	145	179	212	245	279	....	....	75
80	700	119	155	191	226	262	297	....	....	80
85	722	127	165	202	240	278	316	....	....	85
90	743	134	174	214	254	294	....	....	....	90
95	763	141	183	225	267	309	....	....	....	95
100	783	149	193	237	281	....	....	....	....	100

1 3/4-INCH SMOOTH NOZZLE.—3 1/2-INCH HOSE.

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN NOZZLE PRESSURES GIVEN IN FIRST COLUMN, THROUGH VARIOUS LENGTHS OF BEST QUALITY 3½-INCH RUBBER LINED HOSE.									Nozzle Pressure Indicated by Pitot Gage.
		100 feet.	200 feet.	300 feet.	400 feet.	500 feet.	600 feet.	800 feet.	1,000 feet.	1,200 feet.	
20	407	28	35	41	48	54	61	74	87	101	20
25	455	35	43	51	59	67	75	91	107	123	25
30	498	41	51	60	70	79	89	108	127	146	30
35	538	48	59	70	81	92	103	124	148	168	35
40	575	55	67	80	92	105	117	142	169	191	40
45	609	62	75	89	103	117	131	158	186	213	45
50	643	68	84	99	115	130	145	176	206	237	50
55	674	75	92	109	125	142	159	192	225	259	55
60	704	82	100	118	136	154	172	208	244	280	60
65	732	89	108	127	147	166	186	224	263	302	65
70	761	95	116	137	158	178	199	241	281	....	70
75	787	102	124	146	168	190	212	257	304	....	75
80	813	109	132	156	179	203	226	273	320	....	80
85	838	115	140	165	190	214	239	289	....	....	85
90	862	122	148	174	200	227	253	305	....	....	90
95	885	128	156	183	211	238	266	....	....	....	95
100	909	135	164	193	222	252	280	....	....	....	100

2-INCH SMOOTH NOZZLE.—3 1/2-INCH HOSE.

Nozzle Pressure Indicated by Pitot Gage.	Discharge, Gallons per Minute.	PRESSURES REQUIRED AT HYDRANT OR FIRE ENGINE, WHILE STREAM IS FLOWING, TO MAINTAIN NOZZLE PRESSURES GIVEN IN FIRST COLUMN, THROUGH VARIOUS LENGTHS OF BEST QUALITY 3½-INCH RUBBER LINED HOSE.								Nozzle Pressure Indicated by Pitot Gage.
		100 Feet.	200 Feet.	300 Feet.	400 Feet.	500 Feet.	600 Feet.	800 Feet.	1,000 Feet.	
20	532	33	44	55	65	76	87	109	130	**20**
25	594	41	54	67	80	93	106	133	159	**25**
30	651	49	64	80	96	111	127	158	189	**30**
35	703	57	75	93	111	129	147	183	219	**35**
40	752	65	85	105	126	146	166	207	247	**40**
45	797	72	95	118	140	163	185	231	276	**45**
50	841	80	105	130	155	180	205	255	305	**50**
55	881	88	116	143	170	197	225	279	....	**55**
60	920	96	126	155	185	214	244	303	....	**60**
65	958	104	136	168	200	232	263	....	....	**65**
70	994	112	146	180	214	248	282	....	....	**70**
75	1,029	119	156	192	229	265	301	....	....	**75**
80	1,063	127	166	205	243	282	....	....	....	**80**
85	1,095	135	176	217	258	299	....	....	....	**85**
90	1,128	143	186	229	272	....	....	....	....	**90**
95	1,158	151	196	241	286	....	....	....	....	**95**
100	1,189	158	206	253	301	....	....	..	....	**100**

1 CU FT = 7.48 Gal = 62.5#

1 GAL = .1337 cu ft = 8.35#

1 FT head = .43 lbs

1 LB pressure = 2.304' head

1 cu ft per sec = 448.8 gal per min

Velocity in ft per sec = $8.03\sqrt{\text{head in ft.}}$

DIAM.	AREA SQ IN
1/4	.049
3/8	.1104
7/16	.150
1/2	.196
9/16	.248
5/8	.307
3/4	.442
7/8	.601
1 –	.785
1/8	.994
1/4	1.227
1/2	1.767
3/4	2.405
2	3.142
1/4	3.976
1/2	4.909
3/4	5.940
3	7.069
1/4	8.296
1/2	9.621
4	12.566
5	19.635
6	28.274
8	50.265

HEAT COLORS

Red	977
Cherry	1470
orange	2000
White	2370
Dazzling	2730

TEMPERATURES of FUSION

Aluminum	1400°
Copper	2000
Brass	1600
Bronze	1700
Glass	2377
Gold	1900-2600
Iron Cast Grey	2000-2200
" " White	2000
" Wrought	2700-2900
Lead	620
Nickel	2732
Platinum	3100-3200
Silver	1700-1800
Steel	2372-2687
TIN	446
ZINC	782
Fire Brick	4000°
WOOD Chars	350°
" BURNS	500°

To Change
centigrade to Fahrenheit
$F = \left(\frac{C \times 9}{5}\right) + 32°$

Fahrenheit to Centigr.
$C = (F - 32)\frac{5}{9}$

* Softens 1400-1600°

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